Exchange rate volatility, exchange rate regimes and trade flows:

Evidence from the Norway-UK and Norway-US trade functions (1900-2000)

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Preface

During the last decade or two, the global economy has witnessed what some refer to as "the rise of the Dragon". China's impressive economic growth has made the country the second largest economy in the world. This has caught the attention of many economist and policy makers all over the world, and eventually it caught mine too. I suddenly had an urge to learn more about China and this lead me to take a semester abroad at Fudan University in Shanghai. Initially I wanted my thesis to be about China, whether it was about their increasing presence in developing countries in Africa or the alleged currency manipulation. However, even before I went to China, I was already made aware by several professors and members of the Department of Economics at UiO of the potential challenges I could face if I pursued a topic for my thesis regarding China. Most Chinese data are of limited access or unreliable. I witnessed some of this during my semester at Fudan where some of the professors were unwilling to reveal the sources of the data they were using in class.

This thesis is a result of a thorough assessment of different potential topics with respect to the availability of data, time constraint and other resources.

Several people deserve thanks for their contributions to this thesis. First, and foremost, I am grateful to my supervisor Asbjørn Rødseth for his guidance and detailed feedback throughout the writing process. Without his guidance, this process would have been a lot more challenging. Secondly, I wish to thank professor Ragnar Nymoen for making the econometric analysis more understandable and for helping me derive an appropriate econometric model.

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Finally, and most importantly, I want to thank my family, my father Mohamed El-Amrani for his encouraging words and support during the process of writing this thesis. And a special thanks to my friends, especially Daniel Møgster and Hawa Muuse for their encouragement, advice and for being good listeners through my frustrations and achievements. Without you, this would have been impossible.

Needless to say, any remaining mistakes are fully my responsibility.

Abstract

This thesis investigates the impact of exchange rate volatility and exchange rate regimes within a generalized gravity equation and an error correction model using aggregate Norwegian data for exports to the UK and US for the period 1900-2000. My findings suggest that exchange volatility and exchange rate regimes have had a negative but insignificant impact on exports from Norway to United States. On the other hand, I find that the impact of exchange rate volatility on exports to the United Kingdom is positive, both in the short and long run, however the latter appears to be more than four times greater than the short-run effect. Furthermore, the results suggest that an intermediate and floating exchange rate regime[1] have had a very small negative, but insignificant impact on the trade flow.

[1] A fixed exchange rate system is used as the reference regime

Contents

1 Introduction

The most recent depreciation of the Norwegian krone and the decline in the oil price have created new uncertainty in the Norwegian economy. Economists and policy makers are attempting to identify the nature and magnitude of the consequences of these recent events on the rest of the economy. An understanding of the determinants of exchange rates and their relationship with other economic components is crucial to policy makers in order to design the right policy actions.

"A currency war fought by one country through competitive devaluations of its currency against other, is one of the most destructive and feared outcomes in international economics"

The above citation is from James Rickards' book "Currency wars: the making of the next global crisis" (Rickards 2011). According to Rickards, the global economy has already witnessed two currency wars during the twentieth century, but more interestingly, we are in the middle of the third currency war between China and the US right now. Rickards' (2011) statements are perhaps put somewhat extremely, but they are not far-fetched. China's currency has long been a source of attention and controversy, and it has repeatedly been accused by its major trading partners, especially the United States, of manipulating the Chinese currency yuan to an artificially low level.

The exchange rate has played an important role in China's export growth. The undervalued currency has led to high demand for Chinese products and consequently contributed to the accumulation of China's large current account surplus. Because it takes two to tango, the growing current account surplus of China has been accompanied by a large current account deficit in the US[2].

It is important for policy makers to understand the nature of the relationship between exchange rate dynamics and trade. Trade is a major component of a country's GDP and, depending on the nature of the relationship of exchange rates and trade, changes in exchange rates can in principle have a considerable impact on trade and hence on the economy as a whole. China has received enormous attention in recent decades for its impressive economic growth. A perception that circulates the literature is that China's growth is mainly export-led. Given this background, the subject of asserting the effect

[2]However, after the peak in 2006, both China's CA surplus and US' CA deficit have decreased substantially (IMF 2014).

of exchange volatility on exports becomes a very interesting. If the Chinese currency is undervalued, a shift from the current exchange rate policy to a floating regime, where market forces are allowed to determine the exchange rate more freely, would certainly lead to an appreciation of the currency and consequently a loss of competitiveness for Chinese products. According to standard economic theory this would imply that Chinese exports decline. The debates regarding China's exchange rate policy have many aspect. While most of the discussion has focused on the potential of a permanent undervaluation of the Chinese currency, I find the potential impact of exchange rate fluctuations on exports particularly interesting. In summary, if the accusations are correct, a shift to a floating exchange rate regime would in principle have a huge impact on exports and the course of economic growth in China. It is this long-run effect that I find most interesting and which was the motivation for my thesis. However, due to limited access on Chinese data and the given time limit for this thesis I decided to leave this out.

Following the break-down of the Bretton-Woods agreement, and the gradual transition from fixed to floating exchange rate regimes in the aftermath of the break-down, the debates and research regarding both exchange rate dynamics and the relationship between exchange rates and trade were intensified. Most of the existing literature on this matter is therefore from the first two decades after the end of the Bretton-Woods. The literature review given in this thesis reveal that there is no consensus regarding the nature and magnitude of the relationship between exchange rates dynamics and trade.

The focus of this thesis is on the nature of the relationship between exchange rates and trade. The overarching research question is basically: Do exchange rate volatility have an impact on trade flows? This thesis examines the impact of exchange rate volatility and exchange rate regimes on Norwegian exports[3] to the United Kingdom and the United States for the period 1900-2000 in the context of a gravity equation and a cointegration equation based on an error correction model. The choice of countries in this thesis was somewhat random. I decided to start out with the countries that were used in the study of Aristotelous (2001) because I was certain that data were available. Germany and Sweden were considered in the process, but the workload became too extensive.

The analysis i two-fold. Initially, I have used the study of Aristotelous (2001) as a model for my analysis in the sense that my baseline results are based on (OLS) estimation of the same gravity equation as the one applied by Aristotelous. Secondly, because the data

[3]Excluding ships, oil platforms, oil and natural gas.

series related to export to the UK reveal a cointegration relationship, long-run and short-run dynamics of this relationship are studied in the context of an error correction model (ECM).

The rest of this paper is organized as follows: Section 2 presents a brief historical background and literature review on the relationship between exchange rate regimes and exchange rate volatility, Section 3 presents the theoretical framework used in the (initial) analysis, Section 4 contains a description of the data, data sources and how the variables included in the econometric models are measured, Section 5 presents a literature review on the relationship between exchange rate volatility and trade, Section 6 discusses the empirical results and the last section contains a summary and conclusion.

2 Exchange rate regimes and exchange rate volatility

2.1 Historical context

When different exchange rate regimes are evaluated against each other, it is the regimes contribution to stability in the macroeconomic variables that is weighted. The variables that usually found the basis for discussions regarding different regimes, and which reflect the authorities' preferences in monetary policy, are production and inflation. Monetary policy in Norway, as well as in many Western economies, has traditionally, or at least during most of the 20th century, been oriented towards stable exchange rates. So, what type of regime possesses the best stabilizing features when the objective is to minimize exchange rate volatility? The means by which this goal was attained by central banks was by keeping a fixed exchange rate system, and this is mirrored in the dominance of fixed exchange rate regimes in international monetary history.

Qvigstad & Skjæveland (1994) illustrates this earlier perception of monetary policy in their description of Norges Bank's standpoint in the early 1990s when the fixed exchange rate regime of Norway was going toward an end. It is stated that pre-1990, it had almost never been a question of whether Norway should keep a fixed or flexible exchange rate regime, but rather a question of what the currency should be pegged to. When Norway had to give up the currency peg in 1992, the overall perception was that Norway would return to to a fixed exchange rate regime as soon as international terms where suitable for that. Today, most Western central banks have adopted inflation−targeting and conduct their monetary policy in a manner where the main emphasis is put on inflation and production, at least as it appears in the official preferences.

Prior to the 1970s, high inflation was a war and period of distress phenomenon. During the 70s, however, following the breakdown of the Bretton−Woods system, the international economic environment prevailing at the time contributed to larger fluctuations in production and employment as well as high and varying inflation. The purpose of this section is not to point out the determinant elements, but some major events are worth mentioning. First, during the 70s, United States experienced the so−called "productivity slowdown". Although this was not the first time, it was the largest since the end of World War II (Nordhaus 2004). Second, the oil shocks of the 70s and their impact on oil prices had large effects on the terms of trade of major oil traders, including Norway and the United States. Third, even before the end of the Bretton−Woods system, in 1960 the dollar price of gold had increased noticably, and the subsequent devaluation expectations put additional pressure on the US economy. Although the dollar maintained its role as the principal reserve and settlement currency, it was weakened and the United States experienced large capital outflows (Eichengreen 2008, p. 126). Fourth, the Vietnam War escalated in the 70s and the upshot of military costs also posed some additional economic challenges. In addition, this caused the US to subordinate exchange rate stability and price stability to other goals (Eichengreen 2008, p. 128). All these factors combined contributed to the loss of competitiveness of US commodities and the deterioration of the US trade balance.

Norway was at this time building up the petroleum industry and developing the welfare state. The oil shocks of the 70s during which oil prices peaked raised the oil revenues and consequently encouraged demand pressure and inflation. In retrospect, the 70s, and parts of the 80s, are in general referred to as a period of recession.

Another important factor that gradually became more evident was the deterioration of the effectiveness of capital controls as a way to defend the currency peg. Eichengreen (2008) proposes this as a dominant explanation for the shift fixed to flexible exchange rates post−1971. On one hand, the development of new markets and trading technologies led to increasing capital mobility and capital flows of a larger scale than before. As a consequence, pegged rates became both more costly to maintain (large scale capital flows) and difficult to adjust (high capital mobility). On the other hand, prior to WWII, voting rights were limited and labor unions were in a weak position. This offered the governments "protections" from the pressure to trade exchange rate stability to other domestic goals such as price stability and employment. This changed notably after the

Second World War. As Eichengreen (2008) puts it: "(...)universal male suffrage and rise of trade unionism and parliamentary labor parties politicized monetary and fiscal policy making". The trade−off between exchange rate stability and domestic goals became more evident and governments were forced to put inflation and unemployment on the agenda. As a result of this developments, the shift to floating exchange rates became the "inevitable consequence" (Eichengreen 2008).

The rest of this subsection will be a short literature review on the theoretical contributions as well as the empirical studies on the relationship between nominal exchange rate regimes and the real exchange rate variability. This is an extensively documented field, particularly during the 70s and 80s, thus a comprehensive review is beyond the scope of this thesis. My emphasis will therefore be on some of the most referred contributions. As I will express later in section 3.1.4, this thesis operates with nominal exchange rate volatility, and so for my objective, the issue of the relationship between nominal exchange regime and exchange rate variability is clear. There is no doubt that nominal exchange rates fluctuate more under flexible exchange rate regimes than fixed regimes. It is however the real exchange rate between two countries, defined as the relative price of one country's consumption basket in terms of the consumption basket of the other country, that is important for economic agents. It is not the nominal price of a currency per se that is crucial to decision makers, but the purchasing power of that currency. This may explain why the focus in the literature is on the real rather than nominal exchange rate.

2.2 Literature review

As was pointed out by Liang (1998), Mussa (1986,1990), Papell (1992) and Stockman (1983), a considerable bulk of theoretical models of exchange rate determination embody the property of "nominal exchange regime neutrality". This property implies that the real exchange rate is unaffected by the nature of the nominal exchange rate regime. This property is not compatible with actual behavior of exchange rates observed in data. Early in the introduction to the book "Exchange rate economics" by Isard (1995), the author provides a graphical presentation of the short−term variability[4] of Deutsche marks per US dollar, Japanese yen per US dollar an Deutsche marks per Japanese yen from 1957−1994. The figures show a dramatic increase in the short−term exchange rate volatility following the shift from fixed to floating exchange rate regimes in the early 70s. The picture remains the same when he later in the book presents a graphical presentation of the behavior of

[4] Characterized by month−to−month percentage changes (Isard 1995).

both the nominal and the real exchange rates of Japanese yen per US dollar and Deutsche marks per pound sterling for the same time period (Isard 1995). This provides evidence in support of the view that real exchange rate volatility is greater under flexible exchange rate regimes than under fixed regimes. A view that is adequately described by Mussa (1990):

"It is precisely because real exchange rate fluctuations have been closely associated with nominal exchange rate fluctuations that many businessmen and policymakers have expressed dissatisfaction with floating exchange rates".

Mussa goes as far as to claim that the poor usefulness of theoretical models in this matter is a "richly deserved" embarrassment.

Mussa (1986) and Stockman (1983, 1988) are just a few among the researchers that have discussed the "nominal exchange regime neutrality" property exhibited by a large scale of theoretical models. They both reach the conclusion that real exchange rates exhibit higher variability under floating exchange rate systems than under fixed exchange systems. They do, however, provide different explanations of this observed fact. On one hand, Mussa (1986) emphasizes the assumption of sluggish nominal price adjustments. Within a framework of price rigidity and a twofold regime classification, Mussa provides both theoretical and empirical evidence showing that real exchange rates move relatively slower under fixed exchange rate regimes than under flexible regimes. Mussa (1986) shows that for pair of countries with similar and moderate inflation rates, there are substantial and systematic differences in the behavior of the real exchange rate under fixed and flexible regimes. Moreover, Mussa argues that the increased variability of the real exchange rate under flexible regimes is largely accounted for by the volatility of nominal exchange rates. Mussa (1986, 1990) makes a clear distinction between models that incorporate the "nominal exchange regime neutrality" property and those who do not. The implication of this is that the latter type of models are consistent with the observation of "substantial" and "systematic" differences in real exchange rate behavior across regimes. Regarding the former type of models, however, Mussa (1986) states the following:

"virtually any model that assumes that prices of individual commodities adjust on an essentially continuous basis to maintain equilibrium in individual commodity markets is likely to embody this property (nominal exchange regime neutrality)".

This suggest that Mussa was inclined to favor models with sluggish nominal price adjustments in the matter of explaining real exchange rate behavior.

On the other hand, Stockman (1983, 1988) did not entirely dismiss equilibrium models, but tried to reconcile these equilibrium models of exchange rate determination with the observed fact concerning real exchange rate behavior. Stockman (1988) proposes an equilibrium model to explain the greater variability of real exchange rates under flexible nominal exchange rate regimes. Unlike Mussa, Stockman's model is not based on the assumption of sluggish nominal price adjustments. The argument derived from this model is that the scale of the impact of real disturbances (both supply and demand shocks) on real exchange rates are different under the two exchange regimes. Basically, the implication of the model presented by Stockman (1988) is this: real disturbances affect real exchange rates in general, but under floating nominal exchange rates, they will also alter the nominal exchange rate, hence the correlation between nominal and real exchange rates that is observed in the data. Under fixed nominal exchange rates however, "the same disturbances cause changes in the level of international reserves". In the event of losses of reserves for instance, a country with a pegged currency is more likely to impose trade restrictions, capital controls and other restrictions to avoid further reserve losses that would otherwise result in a "forced" devaluation. Assuming current prices can be affected by expected future prices[5], Stockman's key−point is that the expectation that these policies will be implemented in case of reserve losses tends to stabilize the real exchange rate through an increase in expected future relative price of domestic goods. Therefore, as a consequence of this mechanism, the same real disturbance will have a smaller relative price effect under pegged than under floating rates.

Grilli & Kaminsky (1991) (GK) present an alternative explanation for the observed behavior of real exchange rates. In contrast to the non−neutrality of nominal exchange regimes hypothesis propounded by Stockman (1983, 1988) and Mussa (1986, 1990), GK argue that the real exchange rate behavior is more likely to be dependent on the particular periods rather than on the nature of the nominal exchange regime. First, GK examined the real exchange rate variability[6] across different regimes between 1885−1986 and showed that although floating regimes exhibited relatively higher exchange rate variability than fixed regimes, there is one period that stands out.

"The Bretton−Woods period is unique as far as stability of real exchange rate is concerned. This period appears extremely stable when compared to (...) other fixed exchange rate

[5]Inter−temporal substitution (Stockman 1988).

[6]Measured by the mean and standard deviation of the absolute value of the monthly rate of change(Grilli & Kaminsky 1991).

periods" (Grilli & Kaminsky 1991).

This observation is also the basis of their critique of other studies of real exchange rate behavior. GK argue that the strong correlation between real exchange rate variability and nominal exchange regimes presented by Mussa (1986) for instance, is partly related to the fact that most of these studies only focus on the post−WWII period. Second, to confirm their argument, Grilli & Kaminsky (1991) performed a Wald−Wolfowitz (W−W) test to reveal whether the distribution of the monthly rate of change of the real exchange rate is the same across the different regimes that prevailed within their sample period.

The hypothesis of a common distribution is rejected for two cases, one when the whole sample period is examined, and the other when war and devaluation periods are excluded. However, when they also exclude the Bretton−Woods period, the test fails to reject this hypothesis[7]. The results are even stronger when they only examine the pre−WWII period. Grilli & Kaminsky (1991) interpret this as an implication that contemporary institutional factors, and the economic environment in general, should be paid closer attention when examining the behavior of real exchange rate. Grilli and Kaminsky were not the first to propose this. This notion finds support in earlier studies of Frenkel & Levich (1977) and Levich (1985). Levich (1985) points out that the floating period of the 70s and first part of the 80s coincided with a period of great real and monetary turbulence. Furthermore, in an earlier paper, Frenkel & Levich (1977) find empirical evidence suggesting that the times series pattern of exchange rates are more likely to be more dependent on the behavior of underlying economic variables rather than on the de facto exchange rate system. Frenkel and Levich analyzed the similarities of exchange rate behavior across different currencies and time periods using the Box-Jenkins method. Two of their sample periods, one where a fixed exchange rate system was in effect whereas the other is with a floating exchange rate system, showed great similarities in their time series processes. This result is interpreted in similar fashion as Grilli & Kaminsky (1991), i.e. exchange rate behavior do not necessarily depend on the nature of the nominal exchange rate system.

Liang (1998) points out a very important and central issue that might constitute some drawbacks in studies of the behavior of real exchange rates, namely the issue of the exchange rate volatility measure. Liang suggest that a more appropriate measure would be the deviation of the real exchange rate from its long−run trend (mean), and suggest that the measure applied by Grilli & Kaminsky (1991) may cause biased estimates of the

[7]At a 10 percent marginal significance level (Grilli & Kaminsky 1991).

exchange rate volatility and hence weaken the the ability of the W−W test to discriminate between different distributions. Liang (1998) performed the W−W test with a different exchange rate volatility measure and found that the hypothesis of common distributions proposed by GK does not hold over the period 1880−1997. This result does hold even when only the pre−WWII data is used, which is a serious challenge of GK's strongest argument.

"The rationale for using long−run data sets precisely lies in the ability to observe behavior differences across as many different exchange rate regimes as the data can provide. It is difficult to understand the benefit for carrying out the test by excluding the Bretton Woods period. In addition, excluding the post−WWII period leaves about half of the data observation out (...). This may seriously reduce the power of the test" (Liang 1998).

The above citation suggest that Grilli & Kaminsky (1991) might be subject to their own critique regarding the length of the data set applied by among other Mussa (1986).

One of the most influential models in international macroeconomics is Dornbusch's so-called overshooting model which was first described in Rudiger Dornbusch's famous paper "Expectations and exchange rate dynamics" from 1976. The overshooting model, or the exchange rate overshooting hypothesis, provides a theoretical explanations of (high levels of) exchange rate volatility. Similar to Mussa (1986), Dornbusch (1976) assumes nominal price rigidity, an assumption that is regarded as essential for the ability of monetary authorities to influence exchange rate volatility. Other central assumptions by Dornbusch are the assumptions of rational expectations, flexible exchange rates, uncovered interest rate parity, and last but not least, the assumption of long-run purchasing power parity (PPP).

Suppose we are looking at two countries, say A and B, each with their own currency. The latter assumption implies that, in the long run, the purchasing power of one unit of currency of either country A or B should be the same in both countries.
Within a theoretical framework[8], Dornbusch explained how nominal and real exchange rates move from one equilibrium to another. The sluggish adjustments of nominal prices imply that the nominal exchange rate, which is allowed to jump instantaneously when there is a shock to the economy, will adjust in order to compensate for the sluggishness

[8] See Dornbusch (1976), Isard (1995, pp. 119-24) or Rødseth (2000, pp. 204-11) for a more detailed model outline.

in prices. The term "overshooting" refers to the consequence that the nominal exchange rate will overreact in the sense that the realized change is greater than what is necessary to reach the new equilibrium when long-run PPP is assumed to hold. Because (nominal) prices adjust slowly, the real exchange rate will also experience the same changes as in the nominal exchange rate in the short run. In the long run, however, when prices become more flexible, the exchange rate will return to its equilibrium level in line with long-run PPP and the uncovered interest rate parity. Like Mussa (1986), Dornbusch (1976) emphasized the role of short-run nominal price rigidity in explaining short-run volatility in real exchange rates under a flexible exchange rate regime.

There exist a considerable amount of research were the objective is to test the empirical relevance of the overshooting model, Driskill (1981) being among the first contributions. The objective of Driskill is to ascertain the (short-run) response of the exchange rate in response to an unanticipated monetary shock. By analyzing the US dollar/Swiss franc rate over the sample period of 1973-1979, Driskill finds that following a monetary shock there is a short-run exchange rate response by a factor of two[9] compared to the initial monetary shock. This result is consistent with the overshooting hypothesis. However, this study is not representative for the bulk of research testing the Dornbusch model. It is reported that when the model is faced with actual data, the number of studies supporting the overshooting hypothesis only constitutes a small fraction of the overall research (Bjørnland 2009).

3 Method

3.1 Model spesicifation: The gravity equation

The use of the term "gravity" entails that exports are perceived to be related to the trading countries' economic "mass" and distance between them. The general implication of the gravity model of trade is that large countries (in terms of economic size) will trade more with each other and countries further apart will trade less. For instance, theory predicts that two large countries such as the UK and Germany would trade more with each other than they would do with smaller countries, say Norway. Also, German-UK trade would be less than German's trade with France, another large economy which is closer to Germany geographically.

[9]More precisely, the estimated elasticity of response is 2.3.

The gravity equation has gained the greatest empirical success among theoretical frameworks within international economics whose objective is to explain international trade flows (Fratianni 2009, Leamer & Levinsohn 1994). The traditional gravity equation was based on an intuitive explanation of bilateral trade with no theoretical support, however, this has changed since then. Today there exist a considerable literature concerning the theoretical foundations of this equation, which now is considered to have a strong microfounded theoretical basis (Anderson & van Wincoop 2003, Bergstrand 1989, Fratianni 2009, WTO 2012). The gravity equation used in this thesis is taken as given by Aristotelous (2001) who claims it is based on Bergstrand (1989). I therefore assume the model in equation (1) below is theoretically-founded.

As pointed out by Anderson & van Wincoop (2003), a potential weakness of this model is that it does not take account of "remoteness" factors such as distance, tariffs or other trade barriers that most likely will have an impact in bilateral trade. For instance, Anderson and van Wincoop find that national borders reduce trade between industrialized countries by approximately $20-50$ percent. Given this finding they emphasize the importance of including a so-called "multilateral resistance" terms which take account of the factors mentioned above. Without these terms, the gravity equation will not be "well-specified" (Anderson & van Wincoop 2003).
The obtained data on bilateral exports show that the volume of Norwegian exports to UK have consistently been larger than export volumes to the US throughout the sample period. Given the results provided by Anderson & van Wincoop (2003), and the general implication of the gravity equation mentioned initially in this section, my guess is that multilateral resistance terms in equation (1) could potentially explain the differences in trade volumes. On the other hand, empirical studies claim that the inclusion of additional variables, such as distance, do not have any significant impact on the estimated results (Boug & Fagereng 2007, McKenzie 1999). With this in mind, and considering the time constraints for this thesis and the purpose of it, I shall proceed without including the multilateral resistance terms in the estimated gravity model.

The initial gravity equation to be estimated is specified in the following way:

$$
\begin{aligned}
lnX_{ijt} = {} & \beta_0 + \beta_1 lnY_{it} + \beta_2 lnY_{jt} \ + \beta_3 lny_{it} + \beta_4 lny_{jt} + \beta_5 lnP_{ijt} + \beta_6 V_{ijt} \\
& + \beta_7 INTM_{ijt} + \beta_8 FL_{ijt} + \beta_9 WWI_t + \beta_{10} WWII1_t + \beta_{11} WWII2_t \\
& + \beta_{12} WWII3_t + \beta_{13} WWII4_t + \beta_{14} WWII5_t + \beta_{15} WWII6_t \\
& + \beta_{16} WWII7_t + \beta_{17} WWII8_t + \beta_{18} WWII9_t + \varepsilon_t
\end{aligned} \tag{1}
$$

Where X_{ijt} is real exports from country i to country j in period t, Y_{it} is real income of country i (exporting country) and Y_{jt} is real income of country j (importing country), $y_i t$ and $y_j t$ are the real incomes per capita of countries i and j reapectively. P_{ijt} is a measure of competitiveness and represents the relative price of country i's exports to country j's exports denominated in country i's currency, and V_{ijt} is a measure of the exchange rate volatility[10] between the currencies of countries i and j. Variable WWI_t is a dummy variable that takes the value of one during the First World War years and zero otherwise. $WWII1_t$, $WWII2_t$, $WWII3_t$, $WWII4_t$, $WWII5_t$, $WWII6_t$, $WWII7_t$, $WWII8_t$ and $WWII9_t$ are also war-dummies for each of the Second World War period where $WWII1_t$ take the value of one in 1939 and zero otherwise and so on, until 1947 where $WWII9_t$ take the value of one. Variable $INTM_{ijt}$ in equation (1) is the intermediate exchange rate regime dummy that takes the value of one when an intermediate exchange rate regime was in effect between country i and j during the sample period and zero otherwise. Similarly, variable FL_{ijt} is the floating exchange rate regime dummy that takes the value of one when a floating exchange rate regime was in effect between country i and j and zero otherwise. Given the definitions of the exchange rate regime dummies[11], the reference exchange rate system is a fixed regime. The definitions of the two dummies allows one to test whether there is a differential effect of various exchange rate regimes on exports. The coefficients of interest in this study are. β_6, β_7 and β_8.

The estimated results are obtained using ordinary least square (OLS) estimation method.

4 Data

The process of obtaining adequate data has been long and complicated. First, historical data are not very accessible. Second, the data are sometimes not comparable, for instance

[10]See subsection 4.1 for more detail on the measure.

[11]see subsection 1.2 for a detailed regime classification.

due to different measurement methods. The sample period is 1900-2000 and fortunately all the series collected cover this whole period.

This section is divided in two parts, the first subsection will explain how the variables of equation (1) are measured, and provide a detailed summary of all data sources used. The second and last subsection will provide an explanation of the exchange rate volatility measure applied in the empirical examination. Table 12 in the appendix contains the summary statistics of the individual time series I have used.

4.1 Measurement and data sources

As mentioned in section 3, the gravity equation applied here is quite similar to the one applied by Aristotelous (2001)[12] and so the measurement of the variables is not far from Aristotelous' method either.

4.1.1 Exports

The endogenous variables, real exports from Norway to UK and US, respectively, are computed as value of exports from Norway to the respective countries divided by the export price index excluding ships and oil platforms, crude oil and natural gas. Data on the export price index are obtained from different sources. For the period 1920-2000, data on this index are obtained from Statistics Norway (1995) and Statistics Norway (2014*c*), whereas for the period 1900-1919 a price index is computed using values of exports in current and constant prices[13] obtained from Statistics Norway (1965). The Norwegian export price index series are rescaled such that 2000=100.

Data on the exports of different commodities by country are obtained from various publications by Statistics Norway (1995), Statistics Norway (2014*d*) and Statistics Norway (2014*a*). In this respect I have decided to exclude certain commodity groups that are likely to have other dominant determinants of trade than the exchange rate. The commodities excluded are ships and oil platforms, crude oil and natural gas. By doing this I seek to omit fluctuations in total exports that might stem from other determinants specific to

[12] There are in practice two equations, one for each bilateral trade flow investigated in this thesis (Norway-UK and Norway-US)

[13] Export price index =

$$\frac{\text{exports in current prices}}{\text{exports in constant prices}} * 100$$

these commodities. I also seek to restrict poetntial problems that might occur when using aggregate exports data. When using aggregate export data to an analytical purpose such as in this thesis one implicitly assumes that the volatility estimated is similar across sectors of the economy, it is therefore regarded as an improvement to exclude the commodity groups mentioned above.

In order to exclude ships and oil platforms, crude oil and natural gas I have looked closer at the different classifications that have been at use over the sample period. In the years 1900-1938, the commodities were divided according to a classification that was first introduced in 1866. In this, the commodities were divided into 25 main groups with subgroups. At this point in time Norway had still not yet discovered either oil or gas, therefore the only commodity group subject to exclusion is ships which is found under category 24. The "Minimum List of Commodity for International Trade Statistics" replaced this classification in 1939 and lasted until 1951/2. The number of groups was increased from 25 to 48. The oil and gas discoveries had yet not happened and the only commodity group to be excluded, ships, is found under category 46. In 1952/3 Statistics Norway adopted the United Nations classification method "Standard International Trade Statistics", referred to as SITC. Since then, this classification standard has been revised four times; in 1961, 1976, 1988 and last in 2007. Considering data on exports in the period 1953-1987 I have excluded the following commodity categories: 735 (Ship) for the years 1953-1975 and for 1976-1987 I have deducted total annual exports of ships to the respective countries found in monthly bulletins of external trade (SSB, 2014:1c). 313 (Petroleum products) for the years 1959 and 1960, 332 (Petroleum products) and 341 (Gas, natural and manufactured) for the years 1963-1971 and from 1971 until 1987 I have deducted total exports of crude oil and natural gas obtained from an overview of Norwegian exports of crude oil and natural gas by country on (SSB, 2014:1d). For the years 1988-2000 I have used total exports to UK and US excluding ships and oil platforms, crude oil and natural gas (SSB, 2014:1b). There might be some inconsistencies in my deduction regarding the commodity compositions as a consequence of the different classification systems. I have tried to avoid this as best as I can by only excluding commodities that are explicitly stated as ships, crude oil/petroleum or gas products.

Some other comments are in place. First, although the maritime sector amounted to about 30-50 pct. of total export from Norway between 1870-1970 (Regjeringen 2014), the trade statistics on exports to the UK and US show a much smaller fraction. Nevertheless, I have deducted even the smallest values for the matter of consistency. Obtained data on the dependent variable cover the whole sample period (1900-2000). Second, for some years, especially 1970-76, statistics on exports of crude oil and gas have only included quantity measures (not in values) and because of this I have not been able to subtract these values from total exports. Hence, the export values I have used may be higher than than they would be if deduction was possible.

4.1.2 Real income

Real income and real income per capita of Norway, the UK and US respectively, are measured by real GDP and real GDP per capita for Norway, the UK and US. For this I use levels of GDP and levels of GDP per capita for each country in focus measured in Geary-Khamis dollars, also known as the international dollar. These data are obtained from Maddison (1995) and World Bank (2014).

There are at least two reasons why international dollar denominated levels of GDP are chosen here. First, I did not succeed in finding real values for the whole sample period or an appropriate price deflator to convert the nominal values. I do not believe this is impossible, but given my capacity and time limit I argue this would have prolonged my data collection process even more. Second, PPPs, which is the base of the GDP measures used by Maddison, are both currency converted and price deflated. On one hand, this has saved me a lot of work. On the other hand, these measures only reflect different economic sizes of countries in terms of volumes of final goods, and when put on per capita basis they only reflect different levels of economic welfare between the countries. I believe this serves the purpose of this thesis better than nominal values.

An additional comment should be made here. Since this thesis in some sense is a replication of the study performed by Aristotelous (2001), real income per capita is included in the initial gravity equation in order to perform an equivalent study on Norway. The initial results reported in section 5 are based on this equation. However, I have doubts about the inclusion of per capita measures because this practically implies that population growth should enter the model. There is no straightforward link between population growth, at least not in the exporting country, to exports in macroeconomic theory. For this reason per capital measures will be excluded in further analysis following the initial results in section 5.

4.1.3 Competitiveness measure

The gravity equations includes a "competitiveness" variable which is measured in the same spirit as Aristotelous (2001). This variable is defined as the ratio of the exchange-rate adjusted price of exporting country's exports to the price of the importing country's exports (multiplied by the nominal exchange rate). I deviate slightly from this approach by defining the relative export price level, or the competitiveness measure, as the ratio of Norwegian exports price index to the UK exports price index and US exports price index respectively. In doing so, I use the aggregate export price index for Norway excluding ships and oil platforms, crude oil and natural gas, average value index of total exports for UK and unit value index of total exports for US. The Norwegian exports price index is the same as the one used to deflate exports (see 4.1.1). Data on the UK and US exports price indices are obtained from Liesner (1989) and CEIC (2014) for the whole sample period except for the years 1914-1918 where data are missing. However, I have used linear iteration to fill the missing observations. The export price indices of UK and US are also rescaled such that 2000=100. Annual nominal exchange rates are obtained from Klovland (2004).
A presentation of the calculated exchange rate volatilities is presented in table 1 in section 3.2.

4.1.4 Exchange rate volatility

$$V_t = \left[(\frac{1}{m}) \sum_{i=1}^{m} (lnQ_{t+i-1} - ln\bar{Q})^2 \right]^{\frac{1}{2}} \tag{2}$$

Exchange rate volatility is measured using a version of the moving standard deviation approach, as shown by equation (2). Annual exchange rate volatility is calculated using monthly quotations of exchange rates obtained from Klovland (2004). In equation (2), Q is the monthly bilateral exchange rate, $\bar{Q}$ is the average (monthly) exchange rate of year t and m is the order of the moving average, which in this case is 12 months.
Besides being the measure applied by Aristotelous (2001), this is also reported as one of the most common volatility measures used in the literature (McKenzie 1999).

In contrast to Aristotelous, this thesis uses nominal instead of real exchange rates for two reasons. First, the real exchange rate volatility measure would partly reflect fluctuations in price levels and hence will not allow for isolating the risk associated with exchange rate changes independent of price movements. Second, McKenzie (1999) points out that, "in general, it would appear that whilst the distinction between real and nominal exchange rate volatility has generated a lot of debate in the literature, the empirical results suggest that this distinctions does not impact significantly on the results achieved". Data on the exchange rates are obtained from statistics archieves of Norges Bank (Klovland 2004).

Another argument in support of using nominal rather than real exchange rates is that commodity traders or other firms that operate across borders are more concerned about the nominal values of revenues received or prices paid for goods and services, which are determined by the spot exchange rate. Given this, the nominal exchange rate is a better fit. Another, more urgent reason, is that I could not find data on real exchange rates that cover my whole sample period.

4.1.5 Dummy variables

The specification of the war dummies differs significantly from Aristotelous (2001), which uses one single war dummy for all the years during both WWI and WWII. The data on the exports to UK and US, respectively, do not show quite as dramatic changes in the trade volume during the First World War as during the Second World War. Therefore, only one dummy variable is included for the WWI-years, whereas a dummy variable is created for each year during the WWII plus a dummy variable for each of the year 1939, 1946 and 1947. These dummy variables will take the value of one during the specified year and zero otherwise.

4.2 Determining the bilateral exchange rate regimes

The main research question of this thesis is twofold. On one hand I attempt to examine the effect of exchange rate volatility on trade flows irrespective of exchange rate regimes. On the other hand, this question also seeks to provide an answer to whether the exchange rate regimes that spanned the 101−year period between 1900−2000 also had a separate impact in the trade volumes. These two sides are of course not independent of each other. Given that the exchange rate volatility in this thesis is measured using nominal exchange rates, it is realistic to assume greater volatility during flexible or floating regimes than under fixed exchange rate regimes. Papell (1992) refers to this as "one of the clearest stylized facts of international monetary economics". Subsection 2.2 gives a light overview of some of the theoretical and empirical contributions that have been made regarding the relationship between the nominal exchange rate regime and real exchange rate behavior. My approach focuses on the relationship between nominal exchange rate regimes and the nominal exchange rate volatility. The results are presented in table 1 at the end of this section.

In order to incorporate the different regimes in the model, two exchange rate dummy variables are included in each gravity equation. This is done in the same spirit as Aristotelous (2001) in the sense that the reference exchange rate regime is as fixed exchange rate system. Norway has a long tradition with fixed exchange regimes (Qvigstad & Skjæveland 1994), which makes this as suitable choice.
$INTM_{ijt}$ and FL_{ijt} are the exchange rate regime dummy variables in the model. $INTM_{ijt}$ is the intermediate regime dummy that takes the value go one when an intermediate regime was in effect between country i and j (i being Norway and j = UK, US) during the sample period, and zero otherwise. Similarly, FL_{ijt} is the floating regime dummy that takes the value of one when a floating regime between country i and j was in effect and zero otherwise.

When defining the exchange rate dummy variables it is essential to take a look at the history of the international monetary system. Qvigstad & Skjæveland (1994) provide a detailed and complete overview of the development of the Norwegian monetary system since the establishment of the Norwegian central bank in 1816. To provide some perspective on the wider picture on the evolution of the international monetary system, Barry Eichengreen's book "Globalizing Capital" (Eichengreen 2008) and chapter 7 in Norges Banks Occasional paper no. 35 "Historical Monetary Statistics for Norway 1819−2003" have served as useful supplements. In the following paragraphs I will initially operate withe the division given in Qvigstad & Skjæveland (1994), but with further elaborations on important events brought from the supplementary literature mentioned above. The final classification are also presented in table 1 at the end of this section.
Just to clarify, when I refer to a period as one with fixed, floating or intermediate exchange rate regime, I will be referring to the effective bilateral exchange rate regimes (NOK/GBP and NOK/USD), not Norway's exchange rate policy as a whole.

1900−1914: The Classical Gold Standard. As mentioned earlier, Norway has a long tradition of fixed exchange rate regimes, but an international fixed exchange rate system was first established in the 1870s and 1880s when most countries adopted the gold standard, including Norway, the United Kingdom and the United States. The Norwegian krone was pegged to other currencies through the commitment of Norges Bank to convert gold at a fixed rate. This was therefore a period of fixed exchange rates.

1914−1928: A ban on export and import of gold was imposed during WWI and Norges Banks convertibility obligation was suspended on August 1914. It was reinstated in 1916, just to be suspended again in March 1920. In spite of this short reinstatement, this was a period of floating exchange rates (Qvigstad & Skjæveland 1994).

1928−1931: The ban on export of gold was suspended in 1928 and the krone was again pegged to gold. Gold convertibility had been reintroduced in most countries that were former members of the Classical Gold Standard. This was a period of fixed exchange rates.

1931−1933: The Great Depression. UK left the Gold Exchange Standard and suspended convertibility in September 1931. Within a few weeks, Norway and other European countries had followed and the exchange rates were floating again.

1933−1939: The "sterling bloc". Norway unofficially joined the sterling bloc in June 1933 by pegging its currency to the pound. Like the UK, Norway was not back on the gold standard. In the meanwhile, the exchange rate against the dollar was floating until August 1939 when the krone was pegged to the dollar. At this time, the United States were still on the gold standard and from that point Norway was practically back on the gold standard. This was a period of a fixed krone/pound exchange rate, while the krone/dollar exchange rate fluctuated freely until the pegging in 1939.

1939−1946: WWII. Norges Bank was established in London during the Second World War and kept the so-called London-krone fixed. The krone was in principal also still pegged to the dollar. This was a period of fixed exchange rates.

1946−1971: The Bretton−Woods agreement. Limited flexibility was introduced at the end of 1953. To begin with, this was restricted to the European countries including Norway and the UK. In the following years one can observe a minor increase in the variability of the exchange rate between Norway and the UK when compared to pre−1953 data. The krone/dollar exchange rate, however, was kept fixed at the rate 7.15 between 1950 and 1958. By the end of 1958 Norway followed the UK and a number of European countries and made the currency partly convertible. Although the US stayed out of this, this had some practical consequences on the krone/dollar exchange rate. The USD quotations were no loner fixed at 7.15, but Norwegian authorities could in principle choose within the 0,75 per cent bands that were introduced by the end of 1953. Norway reported to the IMF that the band against the dollar was to be between 7.09 and 7.20, which corresponds to the +/_0,75 per cent on each side of the parity (7.15). Since most other countries declared a similar band against the dollar, the Norwegian exchange rate against these currencies, including the pound, could theoretically fluctuate within a band of +/_1,5 per cent of the parity siter occasional paper NB 2004. Although there was some flexibility allowed in the exchange rate system, this was a period of de facto fixed exchange rate regime. Looking at the actual annual exchange rates during this period supports this view.

1971−1978: The Bretton−Woods system was officially over in mid-August 1971 (Qvigstad & Skjæveland 1994) and (Eichengreen 2008). By the end of that year, another agreement was put in place. The Smithsonian Agreement is considered as an attempted continuation of the Bretton−Woods system. This did however, not last very long, it came to an end in March 1973. Meanwhile Norway had joined a European Agreement referred to as the "European snake". According to Klovland, the main argument behind this engagement was that Norwegian authorities desired to ensure stable exchange rates at least against their European trading partners, UK included. The United Kingdom did however exit this agreement just weeks after joining in 1972. When the United States gave up maintaining fixed exchange rate in February 1973, countries within the European snake decided to abolish the system of fixed exchange rate against the dollar. These countries' exchange rates did however continue to fluctuate against each other within a specified band with a maximum width of 2,25 per cent on each side of the parity, but could move freely against the dollar and other currencies outside the agreement
This was a period of various exchange rate regimes. The bilateral exchange rates were kept fixed until the break−down of the Smithsonian Agreement in March 1973. Following this, both the krone/pound and the krone/dollar rates were floating.

1978/9−1992: Norway left the snake in December 1978 and a basket scheme was introduced. This was a period of an intermediate exchange rate regime.

1992/3−2000: Norway failed to defend the currency peg against strong speculative pressure and was forced to allow the currency to float in December 1992. Although Norway did not formally embrace the free float regime until 2001, it is regarded that the event of 1992 was the beginning of the currency floating exchange rate regime. This is regarded as a period of floating exchange rates in this thesis.

On average, volatility during periods when a fixed exchange rate regime was in place has been lower than under flexible regimes. Taking the average of the volatilities listed in table 1 for different regimes, I find the results as expected. Average volatility over the periods of fixed exchange rate regime was 0.0095 for the krone/pound exchange rate

Table 1: Exchange rate regimes and average exchange rate volatility

Period	NOK/GBP regime	NOK/GBP vol.	NOK/USD regime	NOK/USD vol.
1900−1914	Fixed	0.0030	Fixed	0.0123
1914−1928	Floating	0.0497	Floating	0.0588
1928−1931	Fixed	0.0062	Fixed	0.0351
1931−1933	Floating	0.0202	Floating	0.1083
1933−1939	Fixed	0.0095	Floating	0.0314
1939−1946	Fixed	0.0153	Fixed	0.0086
1946−1971	Fixed	0.0024	Fixed	0.0078
1946−1958	Fixed	0.0003	Fixed	0.0128*
1958−1971	Fixed	0.0043	Fixed	0.0026
1971−1973	Fixed	0.0349	Fixed	0.0301
1973−1978	Floating	0.0393	Floating	0.0358
1979−1992	Intermediate	0.0282	Intermediate	.,0415
1993−2000	Floating	0.0231	Floating	0.0283

*When the year 1949 is excluded the volatility becomes 0. The volatility within 1949 was 0.1669 as a consequence of a devaluation against the dollar.

and 0.0162 against the dollar. For floating regimes, the average volatility was 0.0331 for the bilateral exchange rate against the pound, and 0.0525 against the dollar. The exchange rate volatility during intermediate regimes lies in between these two for both the krone/pound and krone/dollar exchange rate. Although the overall picture shows that floating or flexible regimes have exhibited higher exchange rate volatility on average, there are, two periods of fixed exchange rate regime that stand out. Average volatility of the krone/dollar exchange rate during the period of 1928−1931 was 0.0531, which is higher than the average volatility during the periods when a floating regime was in effect. The Great Depression started during this period (1928−31), and the increase in exchange rate volatility is just one of the many economic instabilities that prevailed at this time and throughout the 30s. The second period to stand out is the years right after the breakdown of the Bretton−Woods agreement. In addition to this event, the 70s is characterized as a period of recession [14]

[14]See subsection 2.1.

5 Literature review: Exchange rate volatility and trade flows

The topicality of the relationship between exchange rate volatility and trade flows with regard to both the nature of it and magnitude peaked during the first two decades after the break down of the Bretton-Woods agreement and the following transition to floating exchange rates. Pre-1971[15], most Western countries had little experience with floating exchange rates and the few periods were this had been in effect were in some sense involuntary. Focusing on the 20th century, every period of floating exchange rates were periods of economic distress, like the First World War or the Great Depression in the early 30s. Pre-71, every time the countries were forced into letting the exchange rate float the monetary policy authorities always sought to restore a fixed exchange rate system in order to achieve the then monetary policy goal of stable exchange rates. In the 70s, however, there was a gradual shift of focus in monetary policy conduction from exchange rate stability towards price stability and promotion of output and employment The transition to flexible exchange rate regimes was then "intentionally", and this might explain why the relationship between exchange rate volatility and trade flows became a subject of major concern in the following decades.

Just by skimming the literature one can see that it lacks consensus about the nature and magnitude of the relationship between exchange rate volatility and trade flows. McKenzie (1999) gives a detailed review of both the theoretical and empirical literature. The theoretical contributions can be divided into two blocks, one is in support of the negative hypothesis that exchange rate volatility deteriorates trade, while the other block finds support of the positive hypothesis, that is that exchange rate volatility may promote or stimulate trade. As McKenzie points out, the implications of the various models found in the literature depend to a large extent on the underlying assumptions made about the risk preferences of the agents, the advancement of the financial market in terms of the availability of forward capital markets, and the time horizon of trade transactions.

The rest of this section will be a literature review of some of the empirical contributions. The focus on empirical rather than on both the theoretical and empirical contributions is based on the belief that the former is more relevant for this thesis.

[15]The year the Bretton-Woods agreement was dissolved.

5.1 Aristotelous (2001)

As mentioned earlier, the stating point of this thesis is a replication of the analysis of the relationship between exchange rate volatility and trade flows in the context of a gravity model given by Aristotelous (2001). My baseline estimation results are based virtually on the same model framework as Aristotelous, both with regards to the gravity equation and the exchange rate volatility measure, in the case of Norwegian exports to UK and US respectively for the period 1900 to 2000.

The purpose of this subsection is to give a more detailed presentation of this paper (referring to Aristotelous (2001)). Aristotelous examines the impact of exchange rate volatility and exchange rate regime on the British exports to the US for the period 1889-1999 in the context of a generalized gravity model similar to eq. (1) in section 3. I shall mention that within the literature I have examined, Aristotelous (2001) is the only study that includes exchange rate regime as an explanatory variable of trade volumes in addition to exchange rate volatility. The argument for this is that exchange rate volatility might capture the impact of exchange rate regime on trade. The results indicate that exchange rate volatility had no significant impact on British export to the US, and this observation is consistent even when the regime dummies are excluded. The exchange rate regime dummies on the other hand, show no significant effect (both close to zero) either with or without exchange rate volatility included in the model.

Unlike many earlier empirical studies which have ignored the times-series properties of there data series (McKenzie 1999), Aristotelous checks both the order of integration and potential cointegration relationship within the times series. The order of integration is determined using the augmented Dickey-Fuller and the Phillips-Perron unit root test for which the result indicate that all variables are integrated of order 1, i.e. I(1). Cointegration is tested for using the Johansen likelihood test approach and no cointegration relationship is proved. As econometric theory suggest, Aristotelous proceeds using the first difference of the time series in his estimation that led to the results mentioned above.

5.2 Empirical evidence

The most relevant study in the context of this thesis must be the one conducted by Boug & Fagereng (2007). They examine the impact of exchange rate volatility on Norwegian exports of machinery and equipment to the main trading partners (UK and US included) for the period 1985Q1 to 2005Q4 within a cointegration VAR approach. As a measure of exchange rate volatility they use the generalized autoregressive conditional heteroskedasticity model (GARCH). As noted, the subject of the study of Boug & Fagereng (2007) is very close to the one of this thesis, but the approaches are quite different. The cointegrated VAR approach seems to be a better approach that estimating a gravity equation of the type shown by equation (1) when performing time series analysis because the latter would most likely not take account of particular characteristics of time series, such as non-stationarity and cointegration. Their findings indicate that exchange rate volatility have had no significant impact on Norwegian exports of machinery and equipment and suggest that this causal relationship is "at best weak if present at all" (Boug & Fagereng 2007). However, when they estimate the same VAR but with dummy variables for various events that might have had an impact on the exchange rate volatility in stead of the volatility series obtained using the GARCH measure. Three dummies are included, one for the devaluation episode in 1986, one for transition from fixed to flexible exchange rate regime in 1993 and one for the Asian financial crisis in the late 90s, where the second is the most interesting in this context. The results show a significant negative effect of the Norwegian monetary policy shift of 1993 on exports. This indicates that the regime-switch is associated with increased exchange rate risk leading to a negative effect on trade. Viewed in conjunction with the former result of no (significant) impact of exchange rate variability on trade, there is room to interpret this result as an indication that the shift from fixed to flexible exchange rate system might have discouraged trade through expectations that the new exchange rate system might result in larger exchange rate fluctuations and not from exchange rate volatility directly.

As a demonstration of the point made by McKenzie (1999) about the role of model specification regarding the spread of the empirical results, it is worth mentioning the study of Hayakawa & Kimura (2008). They examine the impact of exchange rate volatility on bilateral trade of machinery and manufactures (respectively) between 60 countries (including Norway) using a gravity equation for the period 1992 to 2005. And unlike Boug & Fagereng (2007), Hayakawa and Kimura find the impact of exchange rate volatility on international trade of machinery to be significantly negative. Furthermore, as their focus is on East Asian trade, they introduce an East Asia dummy to their equations to capture the effect of exchange rate volatility on East Asian trade. The estimated result from this suggest that intra-East Asian trade was discouraged to a lager extent that trade in other regions. They propose the immaturity of forward exchange markets in developing countries and consequently the lack of hedging opportunities as a possible explanation to

this amplified effect on East Asia.
Other have proposed arguments related to this, for instance de Vita & Abbott (2004) suggest that the reason why exchange rate volatility may effect different industries differently could possibly be due to different degrees of openness, profitability and competition across sectors which in turn results in different levels of risk aversion and hence different responses to exchange rate volatility. This type of reasoning can be applied to explain cross−country differences as well as intra−countries differences. The above argument was presented by de Vita and Abbott in the context of their investigation of the impact of exchange rate volatility on UK exports to a number of EU−countries.

Another useful insight from the study of de Vita & Abbott (2004) is the importance of paying attention to various properties associated with time series analysis, such as cointegration. This is important because a general gravity equation would not be an appropriate approach if the series exhibit a long−run relationship or if the relationship have different dynamics in the short run than in the long run. For instance, de Vita and Abbott show that short−term volatility have mostly had insignificant impact on the bilateral trade between UK and the EU countries[16], whereas the long−term volatility turns out to have had a significantly negative impact on UK exports. Given that a well developed forward exchange market exist, this result might indicate that short−term exchange rate risk can be hedged against while this is difficult when it comes to long−term exchange rate fluctuations.

There is also a considerable bulk of empirical literature on the impact of currency unions on trade, particularly with respect to European arrangements such as EU. After the break-down of the Bretton-Woods and the following failed attempt to retain this in the Smithsonian agreement, a number of Western European economies sought to maintain a fixed exchange rate regime to keep their exchange rates stable. The European agreement known as the "European snake" was a result of this in addition to several arrangements leading to what is today known as the European Union (EU). The point is that stable exchange rates were perceived as trade enhancing and this is a dominant driving force in the creation of currency unions. The empirical literature has therefore focused on identifying the impact of such currency unions on trade.
In order to assign the positive impact of a currency union to exchange rate stability one must implicitly assume that exchange rate volatility deteriorates trade. In practice, this

[16] Austria, Belgium, Luxembourg, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Portugal, Spain and Sweden.

becomes a test of the negative hypothesis. Otherwise, there are many other factors that might enhance trade when a country joins a currency union, such as reduced tariffs or increased market access.
For instance, Rose (2000) evaluated the separate effect of exchange rate volatility and currency union on bilateral trade within a gravity model framework covering 186 countries over the period 1970-1990. The outcome suggests that a currency union have a large positive on trade, and a very small but mostly significant negative effect of exchange rate volatility. However, Rose's more striking result is the magnitude of the estimated effect. He finds that bilateral trade between two countries within the same currency union will trade up to three times more than what they would trade with countries outside the union. Rose admits that many of the criteria that are believed to play a determining role in a country's decision of whether to join a currency union or not are ignored in his study. I suspect that by this Rose might also have ignored some other potential explanations to the high estimated effect of a currency union on trade. If we consider EU, for instance, in the context of the gravity theory of trade, many of the member countries have the prerequisites that should enhance bilateral trade such as short distances, similar cultures and in some cases common languages. In particular, if we consider that just decades before these arrangements were established long-distance transport were much higher and cultural barriers more evident. With this in mind, intra-European trade should traditionally be very high according to theory, and empirical observations are consistent with this prediction. Rose (2000) controls for these factors (distance, border line, language etc.) but the magnitude of the estimated impact of a currency union remains the same.

Aristotelous (2006) finds support for Rose's conclusion. He investigates the impact of the Economic and Monetary Union (EMU) on the bilateral trade of each of the EMU countries with the rest of the euro area using an augmented gravity equation covering the period from 1992 to 2003. He finds that the individual country impact of a currency union were mostly positive, but in some cases insignificant or negative. Similar results are obtained by Glick & Rose (2002). The latter study even shows that their estimated magnitude of the effect is the same when the process is reversed, i.e. when a country exits a currency union. They find empirical evidence indicating that if a pair of countries leaves (enters) a currency union, their bilateral trade would be halved (doubled). This is based on as study of over 200 countries and trade regions over the period 1948-1997. However, Thom & Walsh (2002) perform a similar study, although of a much smaller scale, showing that the ending of the Ireland-UK "currency union" in 1979 when Ireland decided to join the European arrangement ERM (Exchange rate mechanisms) had no impact on the Anglo-Irish trade, mostly because these countries already traded freely. This indicated that my previous argument that the effect of a currency union on bilateral trade might be overrated is not totally groundless.

As McKenzie (1999) proposed, researchers have arrived at mixed results largely because they have applied different model specifications and different techniques to compute exchange rate volatility. However, although this has seen some improvements in more recent literature, there is still no consensus with respect to a clear-cut approach for studying the relationship between exchange rate volatility and trade flows.

6 Results

6.1 Initial results: The gravity equation of Aristotelous (2001)

The empirical estimates for equation (1) are reported in table 2 and 3 (below). The adjusted R^2's are 0,9973 and 0,9904 in the NO-UK and NO-US export function, respectively, which at first glance would be taken as an indication that the model is an almost perfect fit to the data. However, such high values of the adjusted R^2 are very rare, if not non-existing, in regression analysis when the underlying model is specified in the appropriate manner. In time series analysis, high R^2 values should be taken as an indication that something is not right, rather than as a measure of the "goodness-of-fit" of the model. Often enough this could imply that the model applied is misspecified. Spurious regression is often the consequence of such misspecification and would typically generate a high R^2. In the context of time series analysis, it is likely that unit roots are not taken into account.
A better measure of the fit of the model in time series would be the root of the mean square error (RMSE), or the standard deviation of the error terms, as it is also called. This measure tells us something about how close the observed data points (of the dependent variable) are to the predicted values of the model, suggesting that low RMSE values mean a better fit. The estimated standard deviation of the error terms are 0.18814 and 0.34884 in the NO-UK and NO-US export function, respectively. There are no standard thresholds of what is considered a low or high RMSE-value. However, the reported RMSE-values (in table 2 and 3) are relatively small compared to the observed data on real exports, therefore I think it is safe to claim that the model *appears* to be a good fit.
The p-value associated with the F-statistic indicate that the traditional F-test reject the

Table 2: Estimation results : Exports from Norway to UK

Variable	Coefficient	(Std. Err.)
Exchange rate volatility: NOK/GBP-rate	0.678	(1.146)
ln(real income: Norway)	-1.079	(0.993)
ln(real income: UK)	5.038**	(1.287)
ln(real income per capita: Norway)	0.241	(1.406)
ln(real income per capita: UK)	-2.584†	(1.376)
ln(relative export price (relative to UK))	-0.613**	(0.161)
Intermediate XR regime	-0.072	(0.090)
Floating XR regime	0.085	(0.069)
WWI (1914-1918)	-0.288*	(0.130)
WWII (1939)	0.039	(0.206)
WWII (1940)	-1.277**	(0.196)
WWII (1941)	-17.663**	(0.207)
WWII (1942)	-17.716**	(0.222)
WWII (1943)	-17.854**	(0.236)
WWII (1944)	-17.799**	(0.246)
WWII (1945)	-4.048**	(0.217)
WWII (1946)	-1.437**	(0.196)
WWII (1947)	-0.691**	(0.192)
Intercept	-30.778**	(4.268)

N	101
R^2	0.998
$F_{(18,82)}$	2023.918
Prob > F	0.0000
Root MSE	0.18814

Explained variable: Exports from Norway to UK (volumes in logs). †, ∗ and ∗∗ denote significance at the 10 %, 5 % and 1 % levels, respectively.

Table 3: Estimation results : Exports from Norway to US

Variable	Coefficient	(Std. Err.)
Exchange rate volatility: NOK/USD-rate	-1.927	(1.250)
ln(real income: Norway)	-14.299**	(3.627)
ln(real income: US)	16.551**	(2.097)
ln(real income per capita: Norway)	12.157**	(3.700)
ln(real income per capita: US)	-16.734**	(2.087)
ln(relative export price (relative to US))	-1.452**	(0.254)
Intermediate XR regime	-0.114	(0.154)
Floating XR regime	0.149	(0.109)
WWI (1914-1918)	-0.391†	(0.211)
WWII (1939)	0.430	(0.364)
WWII (1940)	-1.401**	(0.359)
WWII (1941)	-15.711**	(0.368)
WWII (1942)	-15.908**	(0.382)
WWII (1943)	-16.112**	(0.415)
WWII (1944)	-16.397**	(0.445)
WWII (1945)	-2.833**	(0.409)
WWII (1946)	-0.680†	(0.363)
WWII (1947)	-0.438	(0.358)
Intercept	-46.226**	(6.293)

N	101
R^2	0.992
$F_{(18,82)}$	576.266
Prob > F	0.0000
Root MSE	0.34884

Explained variable: Exports from Norway to US (volumes in logs) †, ∗ and ∗∗ denote significance at the 10 %, 5 % and 1 % levels, respectively.

null hypothesis that all the regression coefficients are equal to zero.

In order to test for autocorrelation I have applied the general Durbin-Watson (D-B) test for first-order serial correlation and the Breusch-Godfrey (B-G) test for higher-order serial correlation. In both the export functions the two tests reject the null hypothesis of no serial correlation with high confidence. The estimated D-W d statistics are 0.74 and 0.89 in the NO-UK and NO-US export functions, respectively. The regression model has 101 observations and 19 regressors (including the dummy variables but excluding the intercept)[17] and the corresponding critical values at 5 % significance level are 1.253 (d_L) and 2.135 (d_U) which are obtained from Savin & White (1977). The null hypothesis of no serial correlation is rejected when d < d_L, which is the case in both export functions. However, rejecting the null hypothesis does not necessarily imply that the error terms follow and AR process, it might as well be an indication that other misspecifications are present. As I will show later, this model turns out to be inappropriate once certain time series properties are considered (see section 6.2).

The coefficient estimates for the exchange rate volatility variables (in both export functions) indicate that this had no significant impact on Norwegian exports to the UK and US at 10 % significance level[18]. However, the magnitude of the estimated coefficient of exchange rate volatility is close to three times larger in the NO-US export function. The same goes for the estimated coefficients of the exchange rate regime dummy variables. Although they are quite small and statistically insignificant in both cases, they are larger in the NO-US export function. According to these result, neither exchange rate volatility nor exchange rate regimes can be considered as statistically significant determinants of the real exports flow from Norway to the UK and US respectively.

The rest of the variables have coefficient estimates that are consistent with standard features of a gravity model. In the case of NO-UK exports, the coefficient estimates of the importer's real income, the relative price ratio ("competitiveness") and the war dummies have the expected signs and significance level of at least 5 %[19], which are consistent with economic theory in addition to being comparable to empirical result achieved by other similar studies, both in terms of sign and magnitude. Among the real income variables, only the estimated coefficient of real income of the exporting country (Norway) is of negligible magnitude in comparison to other empirical results. With regard to the NO-

[17]The results remain however the same when the intercept is included.
[18]The estimated p-values are 0.556 and 0.127 respectively.
[19]Except for the war dummy for year 1939

US export function, all the coefficient estimates for both importer's and exporter's real income and real income per capita are significant at 1 % significance level. They are however surprisingly large in comparison to the NO-UK function and when compared to other estimates in the literature. The coefficient estimate of the relative price ratio is twice the size of the one estimated in the NO-UK case.

However, although the rest show reasonable estimates with respect to sign and magnitude in terms of what others have achieved, I find it hard to give a straightforward economic interpretation of the coefficient estimates of importer's real income per capita, exporter's real income and real income per capita. Standard gravity theory of trade suggest that larger countries, here measure by real (aggregate) income, would trade more. The inclusion of per capita real GDP is argued to be motivated by the aim to distinguish a "size" effect (aggregate income) and an "income" effect (income per capita). Others just state that a pair of wealthy countries (in terms of real income per capita) will typically trade more with each other. If the latter was true, one would expect that the estimates on both importer's and exporter's real income and real income per capita should "contribute" positively to trade.

Given my discussion in the previous paragraph and earlier in section 4.1.2 about the inclusion of real income per capita, two alternative versions of eq. (1) are estimated. The first is an estimation of the NO-UK and NO-US export functions where the series for real income per capita are excluded. The third is the NO-US function where also the intercept is excluded. The reason for the latter exclusion is that the series on real exports to the US start at values close to zero, hence there is no actual intercept in the series. The estimated result are reported in tables 7, 8 and 9 in the appendix.

6.2 Stationarity and cointegration

Stationarity and cointegration are two very important properties in time-series analysis. Normally I would test the individual time series for these properties before conducting any regression analysis, but because the starting point of my thesis is to replicate the study of Aristotelous (2001) in the sense that I utilize the same model framework, I decided to start with estimating equation (1) using the time series without any modification on neither the model or the data series.

The stationarity of the individual time series are tested using the augmented Dickey-Fuller

Figure 1: Real exports from Norway to UK (in logs)

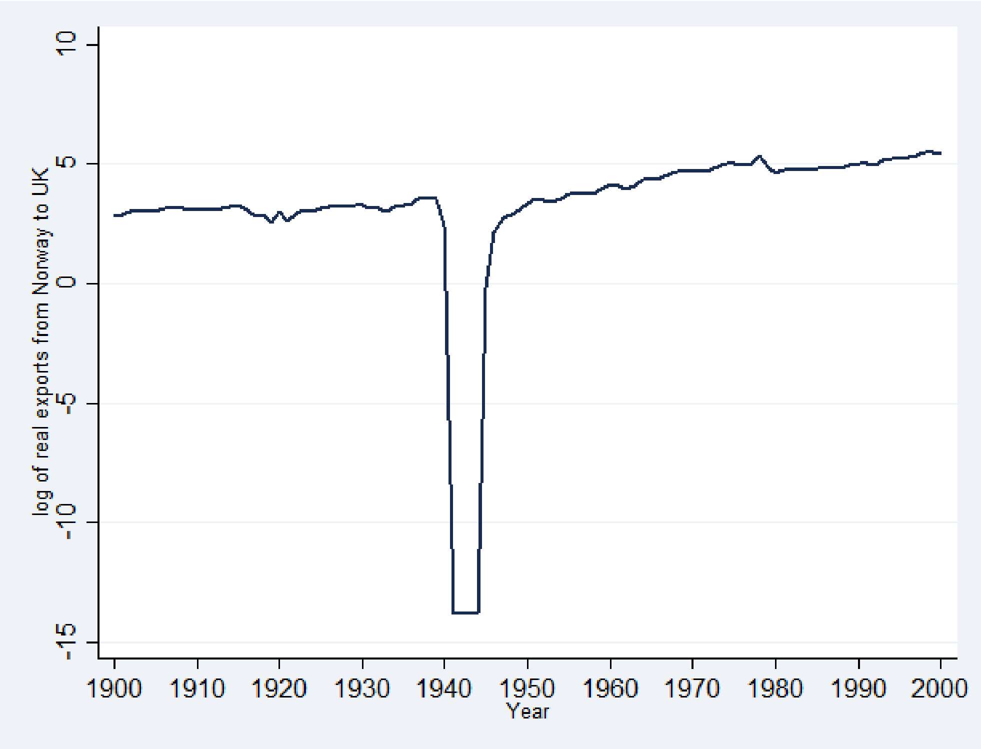
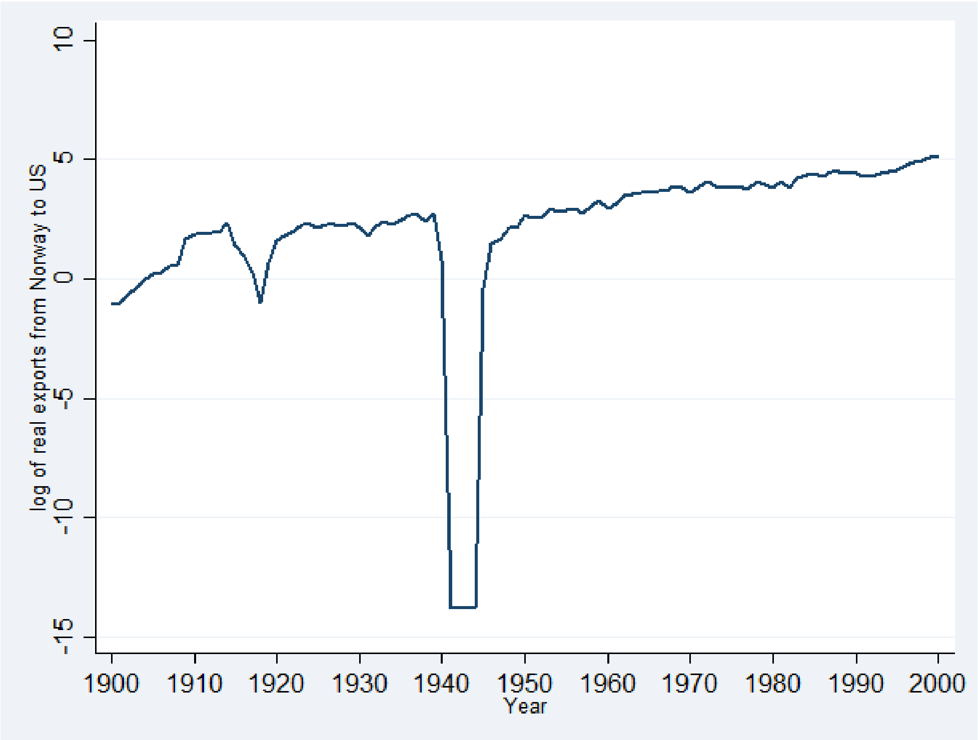


Figure 2: Real exports from Norway to US (in logs)



(D-F) unit root test[20]. The results indicate that the series for exchange rate volatility and relative export price ratios ("competitiveness" measure) are stationary, that is I(0) series. For the exchange rate volatility series, the null hypothesis of a unit root was rejected at 1 % significance level, whereas for relative export prices, the null was rejected 5 % level in the case of competitiveness against the UK and at 10 % significance level in the case of US.

The time series for real income and real income per capita are all I(1) at 1 % significance level. In other words, these series are non-stationary, but their first difference is stationary.

The stationarity property of the series for the dependent variable (Norwegian exports) are less clear-cut. With regard to the series for real exports to the UK, the augmented D-F test rejects the null hypothesis of a unit root at 10 % significance level. The same result is reached for the series on real exports to the US.

To verify these results I perform the modified D-F unit root test, which is believed to have a significantly stronger power than the augmented D-F test (STATA 2014)[21]. When this test is applied, I fail to reject a unit root in the series for real exports to UK using the proposed number of lags[22]. In the case of real export to the US, the modified D-F test rejects a unit root at 10 % significance level. However, by looking at figures 1 and 2 (above), it is clear that both series show signs of a trend. Based on this, I decide to treat the series as non-stationary.

The second property I have examined is the concept of cointegration. In simple terms, cointegration means that two or more of the I(1) series share a long-run relationship (trend). To establish whether there is a long-run equilibrium relationship among the variables in eq. (1) I use the (single equation) error correction model (ECM) test of cointegration. The ECM equation is as follows:

$$\begin{aligned} \Delta lnX_{ijt} = \beta_0 + \beta_1 \Delta lnY_{it} + \beta_2 \Delta lnY_{jt} \; + \beta_3 \Delta lnP_{ijt} + \beta_4 \Delta V_{ijt} \\ + \beta_5 INTM_{ijt} + \beta_6 FL_{ijt} + \alpha_1 lnX_{ijt-1} + \alpha_2 lnY_{it-1} \\ + \alpha_3 lnY_{jt-1} + \alpha_4 lnP_{ijt-1} + \alpha_5 V_{ijt-1} + \beta_7 WWdummies + \varepsilon_t \end{aligned} \tag{3}$$

[20]Using the "dfuller" command in STATA.

[21]The STATA command for this is "dfgls".

[22]Recommended number of lags using the min SC and min MAIC criteria.

The variables are specified in the same way as explained in section 3.1. Moreover, the variables denoted with Δ are given by the first difference of the individual series. The ECM test of cointegration is specified as the following hypothesis test:

H_0: $\alpha_1 = 0$
H_1: $\alpha_1 < 0$

The coefficient of interest is therefore α_1, and if the null hypothesis is true it means that there is no long-run equilibrium relationship between the variables in eq. (1), i.e. no cointegration. The estimated results are reported in table 10 and 11 in the appendix for the NO-UK and NO-US export functions respectively. The critical values applied here are obtained from table 2 in Ericsson & MacKinnon (2002). The null hypothesis of no cointegration is rejected if the estimated t-value is greater (in absolute value) than the assigned critical t-value, obtained from Ericsson & MacKinnon (2002). The results are rather surprising. In the case of the NO-UK export function, I fail to reject the null hypothesis of no cointegration at 1 % significance level[23]. Whereas in the NO-US export function, cointegration is rejected at 5 % significance level[24].

6.3 Norway-US export function

In theory, only the I(1) series are supposed to be converted to their first difference, but for consistency matters and so that interpretation of the results do not became too complicated, I have decided to reestimate equation (1) using only the first difference of all the individual time series. The estimated equation is as follows:

$$\begin{aligned}\Delta lnX_{ijt} = {} & \beta_0 + \beta_1 \Delta lnY_{it} + \beta_2 \Delta lnY_{jt} + \beta_3 \Delta lnP_{ijt} + \beta_4 \Delta V_{ijt} \\ & + \beta_5 INTM_{ijt} + \beta_6 FL_{ijt} + \beta_7 WWI_t + \beta_8 WWII1_t + \beta_9 WWII2_t \\ & + \beta_{10} WWII3_t + \beta_{11} WWII4_t + \beta_{12} WWII5_t + \beta_{13} WWII6_t \\ & + \beta_{14} WWII7_t + \beta_{15} WWII8_t + \beta_{16} WWII9_t + \varepsilon_t\end{aligned}$$

Where i is Norway and j is the United States. The estimated result are reported in table 4 below. The reported adjusted R^2 is still very high (0.98). The estimated standard

[23]The estimated t-statistic is -4.62 and the critical value at 1 % significance level is -4.2168.
[24]The estimated t-statistic is -3.89 and the critical value at 5 % significance is -3.5978.

deviation of the error term (root MSE) has however become smaller than when this relationship was estimated using equation (1), which indicates that this model is a better fit than the previous. Again, autocorrelation is tested for using the Durbin-Watson and the Breusch-Godfrey tests for serial autocorrelation. The estimated D-W d statistic is 2.29 which is greater than the corresponding critical value at 1 % significance level (1.181). This means that I fail to reject the null hypothesis of no serial correlation at 1 % significance level, suggesting the present regression model is an improvement from the previous.

Table 4: Estimation results : Exports from Norway to US

Variable	**Coefficient**	**(Std. Err.)**
ΔExchange rate volatility: NOK/USD-rate	-0.322	(0.718)
Δln(real income: Norway)	2.325*	(0.920)
Δln(real income: US)	0.403	(0.653)
Δln (relative export price (relative to US))	-1.176**	(0.253)
Intermediate XR regime	-0.106	(0.084)
Floating XR regime	-0.005	(0.063)
WWI (1914-1918)	-0.405**	(0.144)
WWII (1939)	0.159	(0.279)
WWII (1940)	-1.610**	(0.304)
WWII (1941)	-14.499**	(0.292)
WWII (1942)	-0.033	(0.305)
WWII (1943)	-0.090	(0.301)
WWII (1944)	-0.003	(0.293)
WWII (1945)	13.056**	(0.293)
WWII (1946)	1.919**	(0.347)
WWII (1947)	-0.155	(0.291)
Intercept	0.019	(0.058)
N	100	
Adjusted R^2	0.9821	
Prob > F	0.0000	
Root MSE	0.2727	

Explained variable: Real export from Norway to US (in log difference). †, ∗ and ∗∗ denote significance at the 10 %, 5 % and 1 % levels, respectively.

The estimated coefficient of exchange rate volatility and the corresponding standard error

indicate that exchange rate variability had no impact on (fluctuations in) Norwegian exports to the United States during the 101 year period between 1900 and 2000. The same goes for the exchange rate regime dummies, as it appears from table 4, the estimated coefficients are close to zero, indicating that exchange rate regimes are both economically and statistically insignificant. I should also mention that the estimated coefficient for exchange rate volatility here is almost six times smaller than what I reached when this equation was estimated on level form.
However, different versions of this equation are estimated in an attempt to improve the significance levels of these variables. First, I exclude the regime dummies to examine whether the effect of exchange rate volatility will be strengthened or not. The result show that the estimated coefficient almost doubles but remains insignificant (the p-value remains the same). Second, I exclude the exchange rate volatility series and again no major changes happen in the estimated coefficients of the exchange rate regime dummies. This suggest that neither exchange rate volatility nor exchange rate regimes can be viewed as significant determinants of Norwegian exports to the US between 1900-2000.

However, the estimated coefficient of the competitiveness measure, or relative export prices, indicate that a 1 % increase in Norwegian export prices cause more than 1 % decrease in US imports from Norway. This is consistent with economic theory which predicts that when a country's commodity prices increase (relative to their trading partners) this country will face lower demand for their products and hence their exports will decrease.

What is most surprising is the coefficient estimates of real income of both the importer and exporter country. For the former, this coefficient went from a very large and significant coefficient estimate (in section 6.1) to become close to zero and insignificant. Whereas the estimate of the coefficient for exporter's real income went from showing a large, negative and significant impact to positive and significant. The signs of both importer's and exporter's income are still reasonable with respect to the earlier discussion; large countries tend to trade more and these variable should therefore have a positive impact. The dramatic change can perhaps be cause by the exclusion of the series for real income per capita.

6.4 Cointegration equation: long-run dynamics

In order to establish the long-run relationship between the variables in equation (1) I have set up a cointegration equation ("kointegrasjonsligning" in Norwegian). The equation is as follows:

$$
\begin{aligned}
lnX_{ijt} = {} & \theta_0 + \theta_1 lnY_{it} + \theta_2 lnY_{jt} + \theta_3 lnP_{ijt} + \theta_4 V_{ijt} + \theta_5 INTM_{ijt} \\
& + \theta_6 FL_{ijt} + \varepsilon_t
\end{aligned}
\tag{4}
$$

Where i is Norway and j is UK, the rest of the variables are specified as described in section 3.1. Notice that the war dummy variables are excluded. The objective of equation (4) is to present the long-run relationship between the variables in it, hence only dummy variables that represent structural changes over longer periods of time should be included. As mentioned earlier, the war dummies are only used as control variables for one year or very short time periods. This equation is arrived at from the ECM in eq. (3) by undertaking a few steps. First, all the difference terms in eq. (3) are set equal to zero and then solved for the dependent variable (lnX_{ijt-1}) in eq. (3)). Second, the long-run coefficients θ_k are obtained using a method found in Bårdsen (1989), as shown here:

$$
\theta_k = -\frac{\alpha_k}{\alpha_1}, \qquad \text{where k = 0,2,...,6 and} \neq 1
$$

Where α_k are the estimated coefficients of the lagged variables in eq. (3) and α_1 is the cointegrating coefficient from eq. (3). The estimated long-run coefficients and the corresponding standard errors are reported in table 5 below. The standard errors of the coefficients are calculated using the following formula, also obtained from Bårdsen (1989):

$$
v\hat{a}r(\hat{\theta_k}) = (\hat{\alpha_1})^{-2}\big(v\hat{a}r(\hat{\alpha_k}) + (\hat{\theta_k})^2 v\hat{a}r(\hat{\alpha_1}) + 2\hat{\theta_k} c\hat{o}v(\hat{\alpha_k}, \hat{\alpha_1})\big)
$$
$$
\text{where k = 0,2,...,6 and} \neq 1
$$

Where $\hat{\alpha_1}$ is the estimated coefficient of the cointegrating coefficient in eq. (3),

The estimated long-run coefficient of exchange rate volatility suggest that long-term fluctuations in the NOK/GBP-rate has had a large, positive impact on Norwegian exports to the United Kingdom. The magnitude of the coefficient suggest that the elasticity response of real export to UK to 1 % increase in exchange rate volatility has been approximately 4,8 % in the long run. However, when looking at the distribution of the exchange rate volatility series, the change from for instance the 20 percentile to the 50 percentile multiplied

Table 5: Estimation results : NO-US long-run coefficients

Variable	Coefficient	(Std. Err.)
Exchange rate volatility: NOK/GBP-rate	4.79	(3.26)
ln(real income: Norway)	-0.53	(0.38)
ln(real income: UK)	2.31	(0.66)
ln(relative export price (relative toUK))	-0.60	(0.35)
Intermediate XR regime	-0.38	(0.19)
Floating XR regime	-0.10	(0.16)
Intercept	-22.2	(4.9)

by the estimated coefficient in table 5 yields a (semi) elasticity response of real exports of 1.2. Whereas the change from the 50 percentile to the 70 percentile gives an estimated elasticity response of 0.016. The differences in the estimated elasticity responses might be due to the fact that the selected percentiles are observations from different exchange rate regimes, where the first "change" is from a period of floating exchange rate regime and the latter is within a fixed exchange rate regime.

The magnitude of the estimated coefficient in table 5 suggest a considerable and significant economic impact of exchange rate volatility on real export from Norway to the UK. The estimated error terms, however, could either imply statistical insignificancy or a slow adjustment process of the long-run relationship between real export and exchange rate volatility. In comparison, the estimated coefficients of exchange rate regimes indicate less economic significance, but the standard errors show relatively higher statistical significance.

The rest of the coefficient estimates have the expected signs and seem reasonable in terms of economic significance. Real income of the importing country has a coefficient estimate is consistent with economic theory, suggesting higher income levels and hence higher demand would increase imports. As discussed earlier, the gravity theory of trade suggests that rich economies tend to trade more with each other which would imply a positive coefficient estimate of real income for the exporting country, but as table 5 shows this model suggest otherwise. However, other studies have arrived at the same result (see Aristotelous (2001) for instance). The long-run coefficient of the relative export prices suggest an economically (consistent with economic theory) and statistically significant long-run impact on real exports. If Norwegian commodities became relatively more expensive (permanently), exports would eventually decline.

6.5 Short-run dynamics

The relevant regression model for this section is eq. (5) below which consists of the Δ-terms in the ECM in eq. (3) in section 6.2.

$$\begin{aligned}\Delta lnX_{ijt} = \beta_0 + \beta_1 \Delta lnY_{it} + \beta_2 \Delta lnY_{jt} \; + \beta_3 \Delta lnP_{ijt} + \beta_4 \Delta V_{ijt} \\ + \beta_5 INTM_{ijt} + \beta_6 FL_{ijt} + \beta_7 WW dummies + \varepsilon_t\end{aligned} \tag{5}$$

The estimated results are reported in table 6 below:

Table 6: Estimation results : Real exports from Norway to UK (short-run)

Variable	**Coefficient**	**(Std. Err.)**
ΔExchange rate volatility: NOK/GBP-rate	0.971	(0.741)
Δln(real income: Norway)	0.545	(0.420)
Δln(real income: UK)	2.361**	(0.561)
Δln(relative export price (relative to UK))	-0.352*	(0.140)
Intermediate XR regime	-0.111*	(0.050)
Floating XR regime	-0.029	(0.045)
WWI (1914-1918)	-0.067	(0.085)
WWII (1939)	-0.038	(0.132)
WWII (1940)	-1.257**	(0.144)
WWII (1941)	-16.781**	(0.155)
WWII (1942)	-5.187**	(1.142)
WWII (1943)	-5.255**	(1.142)
WWII (1944)	-5.089**	(1.151)
WWII (1945)	8.394**	(1.138)
WWII (1946)	1.271**	(0.284)
WWII (1947)	0.183	(0.155)

Explained variable: Real exports from Norway to UK (in log difference) †, $*$ and $**$ denote significance at the 10 %, 5 % and 1 % levels, respectively.

The coefficient estimate of exchange rate volatility suggest the variable is an economically significant determinant of real exports from Norway to the UK, but statistically insignificant as indicated by the estimated standard error. Normally, commodity traders enter a trade contract and conduct the payment at different points in time, the former coming first and the payment later. If there were any changes in the exchange rate in the meanwhile, it would be "too late" to reverse the trade contract. This could perhaps explain why the long-run coefficient of exchange rate volatility is greater than the estimated coefficient shown in table 6.

Surprisingly the coefficient of the intermediate exchange rate regime suggest a small but statistically significant impact. A bilateral intermediate exchange rate regime between Norway and UK was in effect during the 80s. This effect could be correlated with the historical fact that globalization reach new levels during the 80s and 90s when cheap exports from Asian countries, especially China, increased the competition in international trade, which might have discouraged Norwegian exports. The estimated coefficient of relative export prices is statistically significant, but economically less significant than the estimated long-run coefficient in the section above. In the economical sense, this could reflect that many trade agreements or contracts can be fixed over the short-run, hence will fluctuations in relative prices have a smaller impact then in the long-run when this becomes adjustable.

The rest of the estimated coefficients seem reasonable and are comparable with previous results. This can be considered as support of the adequacy of the model.

7 Conclusion

In this thesis I have investigated the impact of exchange rate volatility and exchange rate regimes on exports within a generalized gravity equation and a cointegrating relationship based on an error correction model using aggregate Norwegian data for exports to the UK and US for the period 1900-2000. As a measure of exchange rate volatility I have used a version of the moving standard deviation approach using nominal bilateral exchange rates.

The empirical findings are diverse. First, the gravity equation in its original form appears to be an inappropriate econometric model in my analysis because it fails to take account for time series properties such as stationarity and cointegration. The time series related to export to the UK reveal a cointegrating relationship whereas the data series on exports to the US do not. In the latter case I proceeded the analysis using the gravity equation using the first difference of the individual time series. The findings suggest that exchange rate volatility and exchange rate regimes have had a (small) negative impact, but they are all statistically insignificant.

In the case of UK, the results suggest that exchange rate volatility have had a considerable positive long-run impact on real exports from Norway to UK, whereas it played a significantly lesser role in the short-run. The exchange rate regimes on the other hand, show a negative but minor impact on exports. My suggested explanation for the difference between the short-run and long-run effects of exchange rate volatility is that trade contracts often are "irreversible" in the short-run whereas in the longer run they become more "flexible" and the commodity traders are allowed to adjust both prices and quantities, hence the estimated short-run impact is smaller than the long-run impact.

However, the difference in size and sign of the impacts across the two export destinations is more difficult to explain. One possible explanation could be that the commodity groups contained in the exports to the US are (very) different from those in exports to the UK. A possible subject for further research could be to pursue this question and replicate the study of this thesis using sectoral export data instead, for instance by focusing on a commodity group that constitutes a large fraction of the exports to both countries. Another extension would be to include more countries and investigate the relationship between exchange rate volatility and exports on a bilateral basis as I have done here. This could reveal whether the link between exchange rate volatility and exports differ across countries of destination and perhaps identify why.

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Appendix

This section contain tables that I did not find suitable to include in the text.

Table 7: Estimation results : Exports from Norway to UK (excluding real income per capita measures)

Variable	Coefficient	(Std. Err.)
Exchange rate volatility: NOK/GBP-rate	1.141	(1.123)
ln(real income: Norway)	-0.628**	(0.169)
ln(real income: UK)	2.492**	(0.297)
ln(relative export price (relative to UK))	-0.509**	(0.144)
Intermediate XR regime	-0.128†	(0.075)
Floating XR regime	0.026	(0.062)
Intercept	-23.231**	(2.207)
N	101	
Adjusted R^2	0.997	
$F_{(16,84)}$	2217.173	
Prob > F	0.0000	
Root MSE	0.19064	

Explained variable: Exports from Norway to UK (volumes in logs) †, $*$ and $**$ denote significance at the 10 %, 5 % and 1 % levels, respectively.

The estimated coefficients of the war-dummies are left out in table 7, 8 and 9 because their estimates are very similar to those shown in table 2 and 3 in section 6.1.

Table 8: Estimation results : Exports from Norway to US (excluding real income per capital measures)

Variable	Coefficient	(Std. Err.)
Exchange rate volatility: NOK/USD-rate	-0.196	(1.923)
ln(real income: Norway)	0.605	(0.640)
ln(real income: US)	0.752	(0.670)
ln(relative export price (relative to US))	-0.813*	(0.317)
Intermediate XR regime	-0.278	(0.234)
Floating XR regime	0.304†	(0.158)
Intercept	-15.549**	(3.498)
N		101
Adjusted R^2		0.977
$F_{(16,84)}$		264.741
Prob > F		0.0000
Root MSE		0.54269

Explained variable: Exports from Norway to US (volumes in logs) †, ∗ and ∗∗ denote significance at the 10 %, 5 % and 1 % levels, respectively.

Table 9: Estimation results : Exports from Norway to US (excluding both real income per capital measures and intercept)

Variable	Coefficient	(Std. Err.)
Exchange rate volatility: NOK/USD-rate	-0.384	(2.125)
ln(real income: Norway)	3.264**	(0.252)
ln(real income: US)	-2.114**	(0.200)
ln(relative export price (relative to US))	-0.323	(0.328)
Intermediate XR regime	-0.274	(0.258)
Floating XR regime	0.152	(0.171)
N	101	
Adjusted R^2	0.979	
$F_{(16,85)}$	289.732	
Prob > F	0.0000	
Root MSE	0.5996	

Explained variable: Exports from Norway to US (volumes in logs) †, $*$ and $**$ denote significance at the 10 %, 5 % and 1 % levels, respectively.

Table 10: Estimation results : The ECM test of cointegration: Exports from Norway to UK

Variable	Coefficient	(Std. Err.)
ΔExchange rate volatility: NOK/GBP-rate	0.971	(0.741)
Δln(real income: Norway)	0.545	(0.420)
Δln(real income: UK)	2.361**	(0.561)
Δln(relative export price (relative to UK)	-0.352*	(0.140)
Intermediate XR regime	-0.111*	(0.050)
Floating XR regime	-0.029	(0.045)
1^{st} lag of ln(real exports to UK)	-0.295**	(0.064)
1^{st} lag of exchange rate volatility: NOK/GBP-rate	1.412	(0.934)
1^{st} lag of ln(real income: Norway)	-0.157	(0.119)
1^{st} lag of ln(real income: UK)	0.683**	(0.254)
1^{st} lag of ln(relative export prices (relative to UK))	-0.177	(0.109)
WWI (1914-1918)	-0.067	(0.085)
WWII (1939)	-0.038	(0.132)
WWII (1940)	-1.257**	(0.144)
WWII (1941)	-16.781**	(0.155)
WWII (1942)	-5.187**	(1.142)
WWII (1943)	-5.255**	(1.142)
WWII (1944)	-5.089**	(1.151)
WWII (1945)	8.394**	(1.138)
WWII (1946)	1.271**	(0.284)
WWII (1947)	0.183	(0.155)
Intercept	-6.550**	(2.101)

N	100
Adjusted R^2	0.997
$F_{(21,78)}$	1495.215
Prob > F	0.0000
Root MSE	0.1207

Explained variable: Exports from Norway to UK (volumes in log difference) †, ∗ and ∗∗ denote significance at the 10 %, 5 % and 1 % levels, respectively.

Table 11: Estimation results : The ECM test of cointegration: Exports from Norway to US

Variable	Coefficient	(Std. Err.)
ΔExchange rate volatility: NOK/USD-rate	0.644	(0.915)
Δln(real income: Norway)	3.042**	(0.866)
Δln(real imcome: US)	0.350	(0.608)
Δln(relative export price (relative to US))	-0.929**	(0.266)
Intermediate XR regime	-0.170	(0.113)
Floating XR regime	-0.003	(0.082)
1^{st} lag of ln(real exports to US)	-0.199**	(0.051)
1^{st} lag of exchange rate volatility: NOK/USD-rate	1.988	(1.255)
1^{st} lag of ln(real income: Norway)	0.092	(0.316)
1^{st} lag of ln(real income: US)	0.132	(0.331)
1^{st} lag of ln(relative export price (relative to US))	-0.374*	(0.150)
WWI (1914-1918)	-0.401**	(0.146)
WWII (1939)	0.239	(0.261)
WWII (1940)	-1.411**	(0.281)
WWII (1941)	-14.699**	(0.273)
WWII (1942) -2.979	**(0.832)	
WWII (1943)	-3.078**	(0.844)
WWII (1944)	-3.002**	(0.862)
WWII (1945)	9.850**	(0.881)
WWII (1946)	1.289**	(0.377)
WWII (1947)	-0.244	(0.268)
Intercept	-3.008	(1.888)

N	100
Adjusted R^2	0.986
$F_{(21,78)}$	323.514
Prob > F	0.0000
Root MSE	0.2448

Explained variable: Exports from Norway to US (volumes in log difference) †, ∗ and ∗∗ denote significance at the 10 %, 5 % and 1 % levels, respectively.

Table 12: Summary statistics

Variable	Mean	Std. Dev.	Min.	Max.	N
Real exports to UK in logs	3.149	3.595	-13.816	5.524	101
Real exports to US in logs	2.051	3.567	-13.816	5.195	101
Exchange rate volatility: NOK/GBP-rate	0.018	0.025	0	0.108	101
Exchange rate volatility: NOK/USD-rate	0.027	0.035	0	0.167	101
Real income in logs: Norway	9.871	1.02	8.339	11.633	101
Real income in logs: UK	12.907	0.567	12.127	14.007	101
Real income in logs: US	14.254	0.953	12.652	15.899	101
Real income per capita in logs: Norway	8.693	0.807	7.537	10.13	101
Real income per capita in logs: UK	8.988	0.468	8.396	9.954	101
Real income per capita in logs: US	9.214	0.586	8.316	10.265	101
Relative export price in logs: relative to UK	-2.343	0.189	-2.847	-1.47	101
Relative export price in logs: relative to US	-1.878	0.223	-2.343	-1.088	101